Congress, the numbers corresponding with those on the sketch-map which we give. The first six lie within the United States of Columbia, and the last in Nicaragua and Central America.

1. This line is in the state of Cauca, and extends from the head of the Gulf of Uraba on the Atlantic side to the bay of Chiri-Chiri. The total length between the two oceans is 290 kilometres, of which 50 are canal proper, and the rivers utilised would be the Atrato, Napipi, and Doguado. The volume of excavation would amount to 29,000,000 cubic metres, and of embankment 3,000,000. This canal would require twenty-two locks, and a tunnel six kilometres long. There are a good many objections to a canal along this line, which the American Commission placed only in the second class; besides the locks and tunnel, it would be difficult to make a good port at Chiri-Chiri. It would take nine years to make.

2. The second line is in the States of Cauca and Panama, and runs from the head of the Gulf of Uraba to Darien Harbour and the Gulf of San Miguel. It is 235 kilometres long, 128 being canal, the rivers utilised being the Atrato, Caquirri, Puquia, and Cué, or rather the Tibule, Paya, and Tuyra. It would require 22 locks and 1 kilometre of tunnel, or without a tunnel, extremely deep excavation. The material excavated would amount to 60,000,000 or 65,000,000 cubic metres, and the embankments, &c., to 6,000,000. The tertiary formation along this route presents comparatively soft rocks, and there are fine ports at the two extremities. It would take twelve years to make.

3. The third scheme is in the same State as the previous, but the line goes from Acanti at the entrance to the Gulf of Uraba, to the same Pacific terminus as No. 2, utilising the Tolo, Tiati, Tupisa, Chucunaqua, and the Tuyra. Its length would be 125 miles, of which only 74 would be canal. It would require 70,000,000 cubic metres of excavation; there would be no locks, but a tunnelling of 17 kilometres, which is a great objection, combined with the elevation of the point of departure and the difficulty of sinking shafts. It would take twelve years to make.

4. This route lies in the Chepo district of Panama State, going from the Bay of San Blas to opposite Chepillo Island, at the head of Panama Gulf. The length is fifty-three kilometres, forty-two being canal, the rivers utilised being the Nercalegua, Mamoni, and Bayano. The material excavated would amount to only 34,000,000 cubic metres, there would be no lock, but 16 kilometres of tunnel. This last point is, of course, an objection. The length of time would be ten years.

Nos. 5 and 6 are both in the Colon and Panama departments of Panama State, and, as will be seen, are to a considerable extent coincident. The former is 72 kilometres long, all canal, the River Chagres being made use of. The amount of excavation would be 57,000,000 cubic metres, and of embankment 5,000,000; there would be 25 sluices and no tunnel, and it would take six years to make. No. 6, again, would have no sluices, but tunnelling 6 kilometres long, with 47,000,000 cubic metres of excavation. It would be 75 kilometres long, and the rivers Chagres and Rio Grande would be utilised. Each would take about six years to make, and would cost about the same sum. They are near the Panama Railway, pass through a well-peopled region, and there is no difficulty as to ports. Lieut. Wyse's commission, however, advocate warmly No. 6 scheme, as being preferable to any other. The time wasted in passing locks, the difficulty and expense of maintaining them, and other considerations, induce them to advise that all idea of a canal with locks should be abandoned; and of all possible level canals with tunnels, that numbered 6 seems to this commission altogether the one presenting the most favourable conditions.

The scheme numbered 7 is in the state of Nicaragua and Costa Rica, and passes from Greytown on the Atlantic side, to the Bay of Brito on the Pacific. This line would be 292 kilometres long, 195 being canal, the San Juan, Lake Nicaragua, and the Rio Grande being utilised along the route. The excavations would amount to 48,000,000 cubic metres, and embankments, &c., to 5,500,000, and there would be twenty-one locks and no tunnel. There are too many objections to this line to attract the favourable consideration of the Congress. There are, *e.g.*, the complete absence of ports, difficulty of constructing and maintaining them, insalubrity of nearly the whole of the Atlantic slope, length of the canal, and the political instability of the countries concerned. It would take ten years to make.

As to the cost of the various schemes, we may say that it varies from 475,000,000 to 650,000,000 francs, with a yearly sum for maintenance of from 4,000,000 to 15,000,000.

Some statistics as to the dimensions proposed to be adopted for the basin of the canal may be of interest. The breadth of the canal will be about 20 metres at the bottom, 26 metres at 3 metres high, and according to the nature of the ground, from 32 metres as a minimum at the surface in deep cuttings to 50 metres, when steep banks require 2 in 1 of fall. The increase in breadth which is proposed at 3 metres above the bottom is intended to give more play to ships of large bulk and to increase the water-section, which would thus never be less than 224 square metres. The depth of the canal would be 8½ metres. The curves proposed, with a minimum radius of 3,000 metres, are less pronounced than those in the Suez Canal. The crossing stations will have a breadth of 40 metres at the bottom on a length of 500 metres. The tunnelling will also have a depth of water of 8½ metres, a breadth of 20 metres at bottom, but only 24 at the surface. The smallest water-section will thus be 187 square metres. Above the mean level, on each side, there will be a straight space of 4 metres, then an arch of 30° in a radius of 63 metres; the summit will be semicircular, with a radius of only 2 metres. To satisfy all contingencies the height of the vault above the level of the water will reach 34 metres, which will allow the largest vessels to pass by a little adjustment of their most prominent masts and yards. The entire subterranean section will be 780 square metres, of which 563 will be above water. It is expected that throughout, very little embanking will be necessary.

Thus, so far as the International Commission is concerned, the information to be laid before the conference is full and exact. So far as we have studied the question there seems no serious physical or engineering difficulty in cutting a canal through the American isthmus between the Atlantic and Pacific; probably the great difficulty will be a monetary one, and even this need not, we suppose, be insuperable, if all other difficulties are removed.

ON THE EVOLUTION OF THE VERTEBRATA[1]

II.

AMPHIBIA (*continued*).—When the history of the development of these forms has been thoroughly made out, the terminology can be put into something like proper form. This will have to be done cautiously, for that which we see as one bone in the larva represents, and may become, two or three bones in the adult, and these may represent bones that start as distinct centres in the higher forms.

In the Urodeles there is one bone (the *pterygo-palatine*) in the larva which plays many parts during metamorphosis, and a different part in different species. At first it is related to no cartilage at all, only arising as a cement to a patch of palatine teeth, but after a time the ethmo-

[1] Abstract of Prof. Parker's Hunterian Lectures, delivered at the College of Surgeons, commencing on February 10. Continued from p. 32.

palatine and pterygoid cartilages appear, and it then subdivides, the pterygoid getting the larger half but no teeth, and the ethmo-palatine the lesser half and all the teeth. The form of these parts varies much in the different genera.

The apparent uniformity of the Batrachia, as to the skull especially, is quite belied by what is found on dissection. The disposition of parts in the skull varies greatly.

A careful study of the morphology of the Batrachia suggests many things as to their genetic origin, and accords very accurately with the known facts of their geographical distribution. On the whole the types are more generalised in the west than in the east, and much more so in the south than in the north.

There is nothing in which the frogs and toads differ more from the salamanders than the extraordinary development of the middle ear; the latter always modify a part of the capsule so as to produce a fenestra ovalis and stapes: but in the former, as a rule, the upper element of the hyoid arch is modified into the chain of the middle ear, the spiracular cartilage into the ring of the ear-parchment, and the skin covering the first cleft into the parchment of the ear drum. In certain kinds of frogs and toads these parts are as much arrested as in the salamanders and newts; in all of them that part of

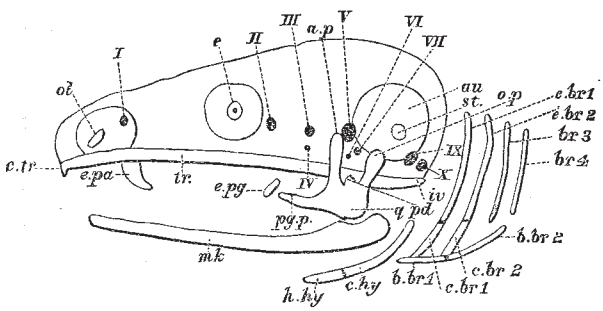

FIG. 2.—Diagram of chondrocranium of young Axolotl. The Roman figures indicate the nerve foramina. *a.p*, ascending process of suspensorium; *au*, auditory capsule; *b.br*, basi-branchial; *br*, branchial arch; *c.br*, cerato-branchial; *c.hy*, cerato-hyal; *c.tr*, coruna trabeculæ; *e*, eye; *e.br*, epi-branchial; *e.hy*, epi-hyal; *e.pa*, ethmo-palatine; *e.pg*, epi-pterygoid; *iv*, investing mass; *mk*, Meckel's cartilage; *ol*, olfactory capsule; *o.p*, orbital process; *pd*, pedicle; *q*, quadrate; *st*, stapes; *tr*, trabeculæ.

the hyoid arch which is developed into the middle ear-chain is later in its appearance than that which carries the tongue.

It is evident that the great polymorphism of these types is due to the influence of their surroundings upon them.

The larger kinds are a long while undergoing metamorphosis, and in their adult condition they possess many bones which can only be found again in the long-extinct Amphibians of the Coal Measures. With regard to small and arrested kinds, which, as a rule, belong to the Notogœa, their arrest in metamorphosis can be paralleled with various stages of development in higher kinds. For example, in *Pseudophryne bibronii*, a small Australian bombinator toad, the auditory apparatus is arrested at the same stage in which we find it in our native kind up to midsummer, that is to say, there is no columella; in *Rhinoderma darwinii*, a South American form, the columella is a thick short wedge of cartilage terminating externally in a fibrous thread, precisely like the rudiment we find in our own native kinds in the beginning of July; and in a small African species of frog, *Gomphobutes*, the columella is developed to the condition of that of our native kinds a month or two later, and it is not ossified.

The relative size of the perfect larva to the adult is extremely variable in the Batrachia. In *Bufo chilensis* the recently metamorphosed young is no larger than a common house-fly, the tadpole being about twice the size, and in *Pseudis paradoxa*, a South American form, which is scarcely larger than our native frog, the tadpole attains the size of a herring or a red mullet. In the case of *Pipa monstrosa* from Surinam, the young when ready to leave the dorsal pouches of the mother are scarcely as large as a honey-bee, but as perfect in their metamorphosis as the young of our native frog and toad at the end of a year; the mother toad is twice as large as a large female native toad.

It is evident that those forms in which the tadpole is of such a large size, have a tendency to remain in the larval condition, and are thus a little in advance of the axolotl, most of the individuals of which are arrested as permanent larvæ, a few only undergoing transformation into true gill-less salamanders (*Amblystoma*).

The manner in which the different kinds of Batrachia are modified, both as to their outward form and skeleton, each one to suit its own particular kind of life, is very interesting and instructive. The little tree-frogs have in their skull a large membranous fontanelle, covered merely with skin, as in young infants; their toes are flattened, and thus they are able to climb with ease and safety amongst the foliage, the colours of which they imitate. Other forms, such as *Pelobates fuscus*, living on the ground, have their small brain encased in dense and almost enamelled armour, and besides this protection, the above-mentioned *Pelobates*, or garlic toad, has the power of giving forth an offensive odour from the skin. This last kind is almost devoid of a middle ear, and the columella is extremely small; the little tree-frogs, on the contrary, have very perfect ears. Thus in *Pelobates* we have a skull approaching that of the Labyrinthodonts, while in the tree-frogs the skull resembles very much that of a shark or skate.

Some large kinds, such as *Ceratophrys dorsata*, have, besides the dense bony plates covering the head, similar large scutes over their shoulders.

The frogs and toads that possess a tongue have their eustachian passages wide apart, as in Mammals, but in the tongueless forms, *Pipa* and *Dactylethra*, the two tubes meet at the mid line, as in birds. They have all two separate occipital condyles, as in Mammals.

Taking the Batrachia through and through, they form a wonderfully perfect chain of types; they do not, however, lead us directly to any existing groups of high Vertebrates, but rather look towards Mammalia than in the direction of reptiles and birds.[1]

REPTILES

Snakes.—The snakes have probably arisen from ancestors which possessed limbs, which, however, have become inconvenient to their descendants, and have therefore been supressed. The boas and pythons, as well as the *Typhlopidæ* and *Tortrices*, have, however, rudiments of posterior extremities.

There is a certain embryonic simplicity in the internal skull, but the outer skull is very perfect and marvellously specialised, as is also the spine. There are no exoskeletal elements whatever behind the head, but in the head there are some small cartilages besides the investing bones, which latter form three-fourths of the skull.

The bones of the skull are the most adamantine to be found anywhere in the vertebrate kingdom, while the cartilage, where it survives (as in the *trabeculæ*), is perfectly elastic, and untouched by the ossifying process. Where sutures persist they are perfectly distinct to old age; when ankylosis takes place along any particular line it early obliterates the least trace of the original suture.

A large part of the base of the skull is more simple and embryonic than anything to be seen in the skull of the

[1] Besides the two papers in the *Philosophical Transactions* (1871 and 1876), the lecturer is preparing a large memoir on the structure and development of the skull in a large number of larval and adult forms of Batrachia.

adult lamprey, while other parts are as much specialised as anything that can be found in the skull and face of a man. There are no *dermostoses*, and no instance is known in which a splint bone (*parostosis*) unites with any part of the ossified endocranium, except in the base of the skull, where a rostrum of membranous origin unites with the basisphenoid. The skull is largely formed of splint bones, and the inner parts of the face are also formed of membrane bones, which, however, represent cartilaginous elements in fishes. The outer parts of the face are formed of bones that have no cartilaginous representatives in the lower forms, but exist as splint bones or dermal scutes in the Ganoids, osseous fishes, and Amphibia. So that in a mere study of the development of the snake, without reference to other types, we should find no difference between the premaxillaries and the maxillaries on the one hand, and the palatines and the pterygoids on the other.

The whole apparatus of the palate and upper and lower jaws is a very loosely articulated structure, and each bone is kept as much as possible in the form of a simple bar or splint.

The hinder part of the endocranium and the auditory capsules are intensely ossified, and contrary to what is seen in any other vertebrata, the orbito- and ali-sphenoids are separately developed in the membranous walls of the skull; they are both very small, especially the former. The three bony elements of the auditory capsule remain permanently separate, but the pro-otic unites with the ali-sphenoid, the epi-otic with the supra-occipital, and the opisthotic with the ex-occipital.

The only visceral elements that are developed behind the mandible are the rod of the columella and the minute stylo-hyal which coalesces with the quadrate.

Lizards.—The lizards form a very large group of reptiles, all of which, like the snakes, have a movable pier to the lower jaw, but which have a very remarkable diversity of external and internal characters. Besides the typical lizards, this order includes the Amphisbænæ, the blind-worms, the chamæleons, and the New Zealand *Hatteria* (*Sphenodon*).

For practical zoology, all that can be seen and handled in an animal without dissection is, of course, readiest and best for classification, but to establish a sound foundation, it is necessary to go much deeper. The brain, heart, and other internal organs present very poor distinctive characters in the families under consideration when compared with the skull, face, spine, and limbs.

In the most serpentiform of lizards there are at least limb girdles even if there are no limbs.

In several kinds, such as the Blind-worms (*Anguis fragilis*) and the Australian *Cyclodonts*, there is a dermal scute inside each horny scale. In the latter and also in the Skinks (*Mocoa*), the underlying parietals and frontals are extensively ankylosed to the overlying bony scutes. In our native sand-lizards the investing bones that lie next the skin, where there are no intervening muscular fibres, become rough and thick, like ordinary dermal scutes; the horny skin over them is thin and has no bony plates under it as in the body. In the larger number of lizards, including the blind-worms, the three normal ventral splint-bones—a pair and an odd one—are seen; in *Hatteria* these are continued along the abdomen segmentally, as in the Plesiosaurs. These bones are suppressed in the chamæleon, which deserves to represent a sub-order by itself, so little has it conformed to the normal type of the lizard.

In the chamæleon the outer bones of the head become crested, scabrous, and fretted with all sorts of markings. In such types as *Monitor*, *Stellio*, and *Iguana*, the cranial roof-bones and the bones of the face are not rough, as in the sand-lizard, nor fretted, as in the chamæleon, but smooth, as in the serpents and birds.

One of the most remarkable things in the skull of some of the types is the retention of rows of bones the counterparts of which must be sought for in the ancient Amphibia of the Coal Measures and in the still more ancient Ganoid fishes of the Old Red Sandstone. In the little nimble lizard, for example, we have two rows of such bones strengthening the eyebrows, and another row over the temporal region, besides a bone flooring the outer nostril, which belongs to the same category.

A sort of anticipation of the hinge of the bird's upper jaw is seen in the sand lizard and in the large stump-tailed lizard of Australia (*Trachydosaurus rugosus*), in which forms a fenestra appears in the orbito-nasal septum. This does not appear in the ostrich tribe, but begins in the Tinamous. Considered evolutionally, this is an exceedingly interesting and instructive fact.

The parietals, which are simply roof-bones, are propped up by a slender rod of bone, the so-called *columella* (*epipterygoid*), which must not be confounded with the bone of the same name in the middle ear. The chamæleons, however, do not possess this bone, and they are also deficient in respect of their ear, having neither the drum and its parchment nor any rudiment of a cochlea.

There is usually only one premaxillary, but in the Skinks and Cyclodonts there are two.

When the birds are spoken of as being genetically related to the lizards, it must be understood that *modern* lizards are not referred to; they are in many respects as

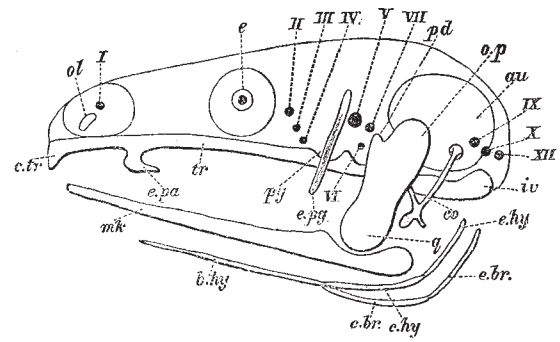

FIG. 3.—Diagram of chondrocranium of Lizard. Letters as before. *b.hy*, basi-hyal; *co*, columella; *py*, pituitary space.

much specialised as the birds themselves, and only form a *side branch*, and not a *leader* of the vertebrate life-tree.

Chelonia (*Turtles and Tortoises*).—The extinction of old, irregular, generalised tortoises has left their descendants in a very neat and orderly state, showing a great uniformity and distinctness from the other reptiles, in the fact that the body is inclosed in a strong bony box formed of the carapace and plastron.

This box is formed of bony plates, covered with horny scales, which, however, do not conform to them. The inner skeleton in the walls and roof of this curious building has become fused with the outer; below there is no inner skeleton, these animals having neither sternum nor sternal ribs, the plastron and the marginal plates of the carapace being formed by ossifications in the dermis. The carapace is principally formed by the bony matter from the spines of the back and of the rib-shafts spreading into the thick overlying web of fibrous tissue.

In some of the Mud Tortoises the edges of the carapace are often soft, and the plastron is very imperfect. In *Chelydra* and the *Matamata* the neck and tail are much longer than usual, and remind the observer of the Plesiosaurs.

The plastron is formed of four bones on each side, the anterior pair being separated by a single median piece, and thus only one of the median ventral bones of a Plesiosaurus or Hatteria is retained.

There are no teeth, the jaws being covered with horn, and forming an efficient shearing apparatus. The facial

bones are few and expanded; the nasals, pre-frontals, and lacrymals are represented by a single bone, and there are no superorbitals. There is no *second* temporal bone, as in lizards, but an additional cheek-bone, the *quadrato-jugal*, unites the jugal to the pier of the lower jaw, a very exceptional thing in lizards (*e.g.*, *Hatteria*.)

The large investing bones have to a great extent aborted the proper internal skull; this is especially the case between the capsules of the ears and the labyrinths of the nose.

In the logger-head and green turtles the cranial compartment has a "shed" or "lean-to" on each side, formed by the parietals, post-orbitals, and squamosals. The pterygoids form the greater part of the bony floor of the skull, between which and the descending wall there is a little bony "prop" corresponding to the *columella* (*epipterygoid*) of the lizard.

The mandible has no *splenial* element, as in bony fishes and frogs. There are two arches developed behind the mandible—the hyoid, or tongue arch, and a second, corresponding to the first gill arch in fishes and Amphibia. The pier of the arch of the lower jaw (*quadrate*) is hollowed into a drum, over which is stretched its "opercular fold," as the parchment, in which there is an annular cartilage. The pier of the tongue-arch is a long slender rod, the *columella*, the proximal part of which answers to the stapes, and the rest to the incus; it stretches between the *fenestra ovalis* and the drum membrane.

This peculiar hollowing out of the quadrate is a promise of the air-cells seen in many of the bones of birds.

The development of the embryo of the Chelonia takes place in essentially the same manner as in birds; yet, in the young of the green turtle, half an inch long, the rudiments of the carapace can be seen.

The parental form of all the modern Chelonia was probably intermediate between the extinct *Rhynchosauria* and the *Plesiosauria*, and the existence in the Cape toad (Dactylethra) of characters that correspond very closely with those of the Chelonia, suggests a relationship between certain ancient forms of the Batrachia and the generalised types from which the Chelonia have sprung.

(*To be continued.*)

GEOGRAPHICAL NOTES

IT would appear as if the War Office authorities expected the special service officers who are on the point of starting for Zululand to find opportunities for doing useful geographical work in that country, as we understand that the Intelligence Department are supplying them with the most recent edition of "Hints to Travellers," published under the authority of the Council of the Royal Geographical Society, and edited by Mr. Francis Galton, F.R.S.

THE news of the death of the Marquis Antinori, the leader of the Italian Expedition to Central Africa, is, we are glad to say, contradicted.

THE Congress of Commercial Geography, to be held at Brussels in September, will be presided over, not by M. Bamps, but by Lieut.-General Liagre, president of the Belgian Geographical Society and perpetual secretary of the Belgian Academy of Sciences. M. du Fief will act as secretary.

NEWS from Leipzig states that the president of the Meteorological Office of that city, Baron A. von Danckelmann has been invited by M. Sibiriakoff to take part in the expedition to the Siberian Arctic Sea, and that he has accepted the invitation, the necessary permission having been readily granted to him by the Saxon Government. The expedition was to sail on May 14.

Les Missions Catholiques publishes an interesting communication from Père Gourdin, a missionary in the Chinese province of Szechuen, in which he gives an account of the little-known tract of country in the south of the province, called Kienchang.

THE last report of Her Majesty's Consul at Newchwang contains much information in regard to Manchuria which is of interest from the standpoint of commercial geography. There are reasons for believing, in his opinion, that in spite of the watershed between the valleys of the Liao and the Sungari, Newchwang will successfully compete with Nicholayesk for the most valuable part of the trade with the latter valley, and those of the two great affluents of the Sungari, the Nonni and the Hurka. A great point in its favour is that the Liao River is remarkably easy of access, while the navigation of the Amur at its entrance is extremely intricate, and is closed by ice for seven months in the year. Colonisation, we are told, is proceeding in the valley of the Yalu-Kiang, the boundary between China and Corea. With regard to the production of opium in regions at a distance from Newchwang, Mr. Consul Adkins says that it is growing in most parts of the province of Fêngtien (South Manchuria), in many parts of the Kirin province, and in a daily increasing area in the southern portion of Eastern Mongolia, notably in the tract of country which lies on the right bank of the Sungari in the angle formed by the reaches of that river above and below its junction with the Nonni, east and south-east of Petuna.

A FURTHER instalment of the *Transactions* of the Asiatic Society of Japan, which has just come to hand, contains some interesting notes of a visit paid last year to the little-known island of Hachijô by Mr. F. V. Dickens and Mr. Ernest Satow, the Japanese Secretary of H.M.'s Legation at Yedo. The island in question, it may be useful to note, is erroneously called Fatsizio on our Admiralty chart; it is the last but one of the chain which extends south of the promontory of Iazu in almost a straight line.

IN a brief account of the work of the China Inland Mission in Burmah we find some notes of interest respecting a visit to the Kah-chen hills near the Chinese frontier. The village visited is situated among the mountains at an elevation of 4,000 feet above the Burmese town of Tsee-kaw. The Kah-chen houses are described as being built of bamboo, and more substantially than those of the Burmese. The roof of each is about 100 or 150 feet in length; at the entrance for some 15 feet the sides are open or merely formed of open bamboo work. The poles which support the roof of this part of the building are ornamented with the heads and horns of buffaloes sacrificed to the *nats* or spirits. On either side of a long passage are small rooms, the first of which is the guest chamber; the kitchen and general sitting-room is at the end of the passage, whence a door, always open, leads into a small raised veranda and which is entirely appropriated to the use of the *nats*, of whom the people are in great dread. The dress of the women is superior to that of their Burmese sisters, than whom they are said to be more modest. All who can afford it, wear a large silver hoop round the neck, and as many strings of red, green, blue, and white beads as they can muster. Their ear ornaments are peculiar; large flaps of ornamented cotton hang from the back of the ear, and tassels or silver tubes are passed through the lobes. All wear large coils of rattan round their bodies, and the younger ones wear bells and cowrie shells. There is, however, one objection to both men and women, viz., their great want of cleanliness.

NOTES

THE University of Edinburgh has sustained a great loss in the unexpected death of its veteran and genial professor of mathematics. Only three weeks ago, in giving the annual address at the graduation ceremonial, he in touching terms